ESRO-SL-74-1
NASA-MF-74-1
REVISION 1

SPACELAB

PROGRAMME REQUIREMENTS

LEVEL I

SEPTEMBER 26, 1974

ESRO-SL-74-1
NASA-MF-74-1
Rev.1
September 26, 1974

SPACELAB

P R O G R A M M E R E Q U I R E M E N T S

LEVEL I

Douglas R Lord

NASA

ESRO

CONTENTS

September 26, 1974

PAGE

PART B

(To be issued)

September 26, 1974

Please address questions or comments on this document to:

Director, Spacelab Program
Code MF
National Aeronautics and Space Administration
Washington, DC 20546

or

Head of Spacelab Programme
European Space Research Organization
114, Avenue Charles de Gaulle
92522 - Neuilly, France

1.0 INTRODUCTION

The purpose of this document is to establish the Level I programme requirements for the Spacelab Programme. The Level I programme requirements are originated by NASA and approved by ESRO. Once established, the programme requirements are jointly controlled by the Head of the Spacelab Programme (ESRO) and the Director of the Spacelab Program (NASA) as necessary to achieve the principal programme objectives:

(1) to provide a versatile capability for accommodating laboratory and observatory facilities suitable for Space Shuttle sortie flights at the lowest practical investment, both in development and operating costs.

(2) to reduce significantly both the time and cost required for space experimentation.

(3) to make direct space research possible for qualified scientists and engineers without the need for full astronaut training.

Part A of the Level I Programme Requirements document (PRD) sets forth the top level definitions, requirements and philosophy for design, operation, product assurance and safety, etc. Part B of the PRD, when issued, will set forth the top level implementation requirements. The PRD is consistent with the overall programme described in the NASA/ESRO Joint Programme Plan and is the principal controlling document on the Spacelab Programme; all planning, direction and implementation shall be in accord with requirements stated herein. Additional Level I direction to the programme may be introduced by changes to the PRD, or, in special cases, in the form of Programme Directives, as required.

The content of this document applies to the design and development of Spacelab, its supporting equipment, facilities and software, and to its operations planning. Except where directly referred to, experiments are excluded from the specific requirements postulated. In particular, the requirements of sections 7.8 and 7.9 are not applicable to experiment equipment.

PART A

2.0 GENERAL

2.1 DEFINITIONS

2.1.1. Spacelab Programme includes the definition, design, and development of pressurized modules and external platforms (pallets), GSE, common payload support equipment, mock-ups, simulators, trainers, software and the equipment needed to interconnect the Spacelab module and/or the Spacelab pallet to the Space Shuttle orbiter. The programme also includes planning for: (1) ground operations, involving experiment integration, checkout and test and maintenance; and (2) flight operations associated with the crew, the Spacelab, and typical experiments, including mission control, crew training and data management.

In accordance with the Memorandum of Understanding, ESRO is responsible for the development of the Spacelab concept agreed on jointly by NASA and ESRO including flight hardware, software and ground support equipment. ESRO will direct the design, development, manufacture, qualification, acceptance test and delivery to the U.S. of one Spacelab flight unit, one engineering model, two sets of Spacelab ground support equipment, including a Spacelab to orbiter interface simulator, initial spares and documentation and will also provide sustaining engineering through the first two Spacelab flights. NASA will procure additional flight units, GSE, and services as required. NASA will also direct the design, development, manufacture, and qualification of the transfer tunnel, an orbiter to Spacelab interface simulator and Spacelab crew training equipment.

NASA will have primary responsibility for all operational activities subsequent to the delivery of the Spacelab, including experiment integration, crew training, checkout, flight operations, refurbishment, data acquisition, preliminary processing and distribution.

2.1.2. Spacelab is composed of modules and pallets suitable for accommodating instrumentation for conducting science, applications and technology activities on Shuttle sortie flights. On a given flight the Spacelab configuration can be comprised of a module only, a pallet only, or a combination of a module and a pallet. Spacelab will always remain attached to the Shuttle orbiter throughout its flight.

2.1.3. A Spacelab module is a pressurized manned laboratory suitable for conducting science, applications and technology activities on Space Shuttle sortie flights. A section of the module will be devoted primarily to subsystem support to experiments in the module or mounted on the pallet (basic module), and one or more additional sections may be devoted primarily to housing experiment equipment and activities (extension module).

2.1.4. A Spacelab pallet is an unpressurized platform for mounting telescopes, antennae and other instruments and equipment requiring direct space exposure for conducting science and applications activities on Space Shuttle sortie flights. The pallet experiments will be operated automatically or remotely from the Spacelab module, the orbiter cabin or directly from the ground. In each case an adequate interface for subsystem support will be provided. The pallet may be composed of segments. In the pallet-only mode, the pallet is flown without a module. In the latter case, an interface unit or igloo will be provided with support subsystems in one or more pressurized compartments.

2.1.5. A Spacelab flight unit comprises all system constituents necessary to assemble any flight configuration.

2.1.6. The Engineering Model is a full size structural model, dimensionally correct (including interfaces), with subsystems functionally identical to the flight unit (but not necessarily fully qualified), and comprises all system constituents necessary to assemble any flight configuration. The module will represent the flight unit in all respects as it is known at the time of Critical Design Review (CDR) and its configuration will be maintained to reflect the flight configuration.

2.1.7. A sortie flight is of relatively short duration (nominally seven (7) days extendable up to thirty (30) days) and is conducted in low earth orbit using the Shuttle orbiter and equipment attached to it for experiments, observations and other space activities.

2.1.8. Baseline - A fundamental reference with regard to programme plan, configuration, operations and experiments and the basis for comparison of alternatives.

2.1.9. Fail safe - defined as the ability to sustain a failure and retain the capability of terminating a flight without injury to crew personnel or vital Spacelab subsystems.

2.1.10. Acceptance - the formal process governing the delivery of hardware and software.

2.1.11. Ground Support Equipment (G.S.E.) - includes all Spacelab specific equipment and software required for transporting, ground handling, testing, integrating, refurbishing, reconfiguring, checkout, prelaunch and post-landing operations. This also includes simulators needed for verification and checkout of interfaces.

2.1.12. Transfer Tunnel - a variable length tunnel providing access to the Spacelab module from the orbiter and also to an EVA hatch.

2.1.13. Common Payload Support Equipment (CPSE) - equipment other than basic Spacelab and Shuttle subsystems, such as a scientific airlock, needed by more than one Spacelab experiment.

2.1.14. Racks - removable/reusable assemblies that provide structural mounting and connections to supporting subsystems (power, thermal control, data management, etc.) for experiment equipment which is housed in the pressurized module.

2.1.15. Flight Success is defined as the proper functioning of the Spacelab, its subsystems, and the experiment support equipment provided to the users (but not of the experiments themselves).

2.2 RELATED DOCUMENTS

The list below is included here for reference purposes only. The specific applicability to the Spacelab Programme is as stated in each document.

(1) Memorandum of Understanding between the National Aeronautics and Space Administration and the European Space Research Organisation for a Cooperative Programme Concerning Development, Procurement and Use of a Space Laboratory in Conjunction with the Space Shuttle System, dated 14 August 1973.

(2) NASA/ESRO Joint Program Plan for Spacelab, dated September 26, 1974.

(3) Space Shuttle Program Requirements Document, Level I, dated March 12, 1974, Revision No. 6.

(4) Space Shuttle System Payload Accommodations, Level II, Program Definition and Requirements, Volume XIV, Revision C, JSC 07700, dated July 3, 1974

(5) Space Transportation System/Spacelab Safety Requirements for Payloads, Level I planned for issuance TBD.

(6) Spacelab User's Guide, planned for issuance November 1974.

(7) Spacelab Systems Requirements Document, Issue 5, Level II, dated October 1974.

(8) Spacelab Payload Accommodations Handbook, Level II, October 1974

(9) Joint NASA/ESRO Spacelab Payload Requirements, planned for issuance October 1974.

(10) Natural Environment Design Requirements for the Sortie Module, TMX 64668, 2 June 1972.

(11) Baseline Characteristics - 1979 - 1984 of the Space Flight Tracking and Data Network, including Tracking and Data Relay Satellite System (TDRSS), dated April 17, 1973.

2.3 UNITS

Drawings, specifications, weight statements and summary engineering data will utilize the International System of Units (M.K.S.A.). Both International System of Units and common British engineering units will be used in Shuttle/Spacelab interface documents and drawings. The use of both systems of units in other areas will be mutually agreed upon by ESRO and NASA.

2.4 DELIVERY SCHEDULE

2.4.1 The First Flight Unit of Spacelab, necessary GSE, software, and selected items of common payload support equipment will be delivered to the U.S. and will be ready for the installation of experiments by early 1979.

The acceptance tests will be conducted with both ESRO and NASA participation to assure specification compliance for all deliverable items. Delivery of hardware and software will be accompanied by a data package with instructions for reassembly and retest by the U.S. and with a list of all open items (e.g. changes, etc.).

2.4.2 An Engineering Model of a Spacelab flight unit will be available in the U.S. one year prior to the delivery of the First Flight Unit for use in maintenance and refurbishment procedures development, experiment integration verification, crew training and flight simulation.

3.0 SYSTEM

3.1 DESIGN MISSIONS

3.1.1. Spacelab will be designed for Experiment Missions supporting multidiscipline or single discipline science, applications and technology. The experiment objective may constitute a total Shuttle flight objective or may be combined with other major flight objectives (ref. par. 3.1.2.). Orbital inclination of experiment missions will be compatible with Shuttle performance:

28.5 - 57 Deg. from ETR and

56 - 104 Deg. from WTR

3.1.2. The Spacelab design shall not preclude Satellite Deployment and Retrieval Missions which can be conducted on the same flights as experiments.

3.2 DESIGN LIFE

As a design objective, Spacelab shall be capable of use for a minimum of 10 years and of low cost refurbishment and maintenance for approximately 50 flights of 7 days duration.

3.3 FLIGHT SUCCESS

3.3.1. The Spacelab will be designed for a high probability of flight success. The goal will be 0.95 (independent of Shuttle and Network reliability) for 7-day flights.

3.3.2. The redundancy requirements for all Spacelab subsystems (except primary structure and pressure vessels) shall be established on an individual basis, but shall not be less than fail safe for all subsystems. Primary structure and pressure vessels shall be designed for safe life (see par. 3.2).

3.4 CREW

3.4.1. The Spacelab crew (men and women) will consist of one to four "payload specialists" who may be principal investigators and may have minimal astronaut-type training. These are in addition to the orbiter crew which consists of a commander, pilot and mission specialist.

The mission specialist will be the principal onboard expert for both orbiter and Spacelab basic subsystems and will monitor, control, activate, trouble shoot, maintain and deactivate these subsystems as required. He will also assist the payload specialists on a time available basis. The commander and pilot will operate the orbiter in support of the flight and will assist the mission specialist and payload specialists on a time available basis.

3.4.2. For design of the Spacelab, the following numbers of personnel shall be considered:

Total in orbit	Available for Spacelab activities-full time basis
Maximum 7	4
Minimum 4	1

The Spacelab module will be designed to accommodate up to three persons continuously and up to four persons during crew shift overlap. The Shuttle orbiter will provide sleep, galley, waste management, personal hygiene, health and well being accommodations as well as seating during ascent, reentry and landing for all crew members.

3.4.3. The weight of all personnel in excess of four including the weight of their seats, equipment and provisions (normal and emergency) will be chargeable to Spacelab. Expendable provisioning for 28 man-days is provided by the orbiter and provisioning storage capacity (but not the expendables themselves) is also provided for an additional 14 man-days.

3.5 WEIGHT AND CENTER OF GRAVITY

3.5.1. The total design weight of Spacelab including:

- Mission independent subsystem support (essential subsystems);
- Mission dependent subsystem support (CPSE, recorders, etc.);
- Transfer tunnel;
- Mission independent orbiter support equipment (one energy kit, heat rejection kit, and bridge fittings);
- Spacelab payload (experiment equipment, instrument pointing systems, crew members and crew provisions in excess of four, non-expendable provisions for missions longer than seven days, and any orbiter provided mission dependent support equipment such as OMS kits, second manipulator and TDRSS antenna, etc.);
- Program weight reserve;

but excluding expendables will not exceed 14,515 kg (32,000 lbs).

The total Spacelab launch weight may exceed 14,515 kg up to the limit set by the Space Shuttle system launch capability for the particular mission but in no case exceeding 29,484 kg (65,000 lbs).

3.5.2. The following weights will be available for Spacelab payload on all seven-day missions:

Configuration	Spacelab Payload Weight
Long module	5500 kg (12,125 lbs)
Short module plus 6 to 9m pallet	5500 kg (12,125 lbs)
Pallet only, 15m pallet length	8000 kg (17,640 lbs)
Pallet only, 9m pallet length	9100 kg (20,065 lbs)

The above payload weight requirements are applicable with the following mission dependent equipment weights: 826, 723, 340, 295 kg respectively, and the following orbiter support equipment weights: 435, 560, 585, 710 kg respectively. Variations from these mission dependent and orbiter support equipment weights due to hardware growth will be accommodated by the reserves (see 3.5.3.). Variations resulting from user requirements on specific missions will result in upwards or downwards adjustments to the payload.

3.5.3. The programme reserve constitutes a margin for Spacelab and payload contingency and growth. It is the intent of both ESRO and NASA that at least 20% of the values listed in 3.5.2 (except for the 9m pallet case for which at present only 16% is attainable) will be reserved for payload growth and that 20% of the Spacelab development hardware weights (Spacelab, transfer tunnel, mission dependent and orbiter support equipment) be reserved for Spacelab growth.

Tentative reserves for payload, Spacelab and a non-allocated portion are given below. It is intended to review this preliminary appropriation at PRR and to make final adjustments at SRR.

Configuration	1. Program Weight Reserve	2. Payload Growth Reserve		3.* Spacelab Development Reserve		4. Non-Allocated Reserve
	kg	kg	In % of Payload Requir.	kg	In % of SL Dev. Hardware	kg
Long module	3297	1100	20%	1143	20%	1054
Short module plus 9m pallet	2624	1100	20%	1279	20%	245
9 m pallet**	2138	1485	16%	653	20%	0
15m pallet***	2426	1600	20%	817	20%	0

* Includes mission dependent equipment, transfer tunnel and orbiter support equipment.
** Pallet segments separately suspended
***Pallet suspended in two groups: 2 segments and 3 segments.

The payload growth reserve and the non-allocated weight reserve will be jointly controlled by ESRO and NASA, whereas one quarter of the Spacelab development weight reserve (colume 3) will be jointly controlled, and three quarters thereof by the agency responsible for the related hardware development, i.e. by ESRO (for Spacelab and mission dependent equipment) and by NASA (for the transfer tunnel and orbiter support equipment).

3.5.4. The combination of weight and center of gravity for the Spacelab (as defined in 3.5.1), with and without expendables, must fall within the limits specified in reference paragraph 2.2(4) during both ascent and reentry.

3.6 LIMITING DIMENSIONS

The dynamic envelope of Spacelab and tunnel shall not exceed a cylinder of 4.57 m (15 ft) in diameter (except for mounting fittings), and 18.29 m (60 ft) in length (or less when particular flights require items such as Orbital Maneuvering System propellant kits).

3.7 MODULE SIZE

The size of the minimum module will be such that it accommodates approximately 5 m^3 (175 ft^3) of experiment equipment volume. The size of the largest module will be subject to the requirement for a cylindrical side wall length of approximately 4.5 m (14.8 ft) fully available for experiment use.

3.8 PALLET SIZE

As a design goal a length of 15 m (49 ft) should be achievable with combined pallet segments.

3.9 TRANSFER TUNNEL

3.9.1. The transfer tunnel will be sufficiently variable in length to accommodate the most extreme positions of the Spacelab pressurized module in the orbiter payload bay required to meet center of gravity constraints.

3.9.2. The tunnel will also permit ground installation of a docking module at the forward end of the payload bay for special flights.

3.9.3. The transfer tunnel will provide access to the payload bay for scheduled and unscheduled EVA and for rescue EVA, except on special missions carrying a docking module.

3.9.4. The tunnel will be designed in such a manner as to permit installation of secondary payloads above it.

3.9.5. The tunnel design will ensure minimum impact on the overall Spacelab in terms of weight and subsystem support.

3.10 SPACELAB SUBSYSTEMS - GENERAL

(Also see section 5.0)

3.10.1. The use of available subsystems, assemblies and components in the Spacelab, and all necessary flight and ground support equipment shall be considered. These items may include standard commercial and military components and those developed for other programmes including the Shuttle. Availability of additional units and spares during this operational phase is an important consideration.

3.10.2. Subsystems will not normally require ground operations support and monitoring during orbital operations.

3.10.3. The crew time required for subsystem monitoring, control and on-orbit maintenance will be minimized.

3.10.4. The design of the basic module and the pallet interface unit will facilitate the functional separation of resources management from payload data management in both flight and ground operations.

3.10.5. Limited support to payloads during prelaunch, launch, reentry and post-landing periods, over and above the basic capabilities of the orbiter and Spacelab subsystems will be provided by the Spacelab, the Shuttle, and/or the payloads.

3.11 SPACELAB SUBSYSTEMS - SPECIFIC

3.11.1. Spacelab air revitalization subsystem (ARS) will provide an oxygen/nitrogen mixture at one atmosphere pressure and will be able to operate with all hatch doors open or closed between the orbiter cabin and the module.

3.11.2. The Spacelab module will have:

(a) Nearly continuous real-time wide band digital, analog and video data transmission through the orbiter and a relay satellite (TDRSS).

(b) High data rate recording, digital, analog and video.

(c) Tape and film storage.

3.11.3. As a goal the command and data management subsystem (CDMS) will minimize the need for ground support equipment.

3.11.4. The Spacelab will have its own command and data management subsystem with dedicated computers to perform subsystem functions separately from experiment functions, and both functions independently of the Shuttle orbiter computers.

3.11.5. A precision instrument pointing subsystem (IPS) which can be mounted on the pallet will be provided.

3.12 MARGINS

Where possible, safety factors and design margins will be sufficiently large to minimize a costly verification and qualification effort during the development phase or retesting during the operational phase.

3.13 EXTENDED FLIGHT DURATION

The Spacelab will incorporate design provisions to extend the flight duration up to 30 days including all necessary stowage compartments, volume and distribution systems for expendables and subsystem maintenance and redundancy features.

3.14 LABORATORY VERSATILITY

3.14.1. The Spacelab module and pallet will be configured to provide the maximum versatility for experiment payload accommodation.

3.14.2. Laboratory utility to the users will be a major consideration in all design and operational concept decisions.

3.14.3. As a goal, the facilities provided by the Spacelab will accommodate users' science, applications, and technology equipment with minimum costs to the users for modification or adaptation.

3.15 COMMON PAYLOAD SUPPORT EQUIPMENT (CPSE)

The flight units will include at least the following CPSE:

(a) two large removable scientific airlocks.

(b) one high quality window and one view port for science, applications, and technology observations.

(c) one or more work benches.

(d) a film vault.

(e) a vacuum vent.

3.16 DEPLOYMENT

All Spacelab related devices which are extended on orbit out of the payload bay must have emergency provisions for retraction or jettison.

3.17 HABITABILITY

The Spacelab module will provide the crew with comfortable, efficient and safe working conditions with easy access to the living quarters in the Space Shuttle orbiter. The module will provide a shirtsleeve environment and will be pressurized to one atmosphere.

3.18 INTERNAL ARRANGEMENT

The internal arrangement of the Spacelab module will be generally suitable for a gravity (single orientation) environment with the floor(s) parallel to the cylinder axis in order to facilitate:

- experiment installation at a user's home site with minimum fixtures and scaffolding,
- refurbishment and turnaround operations,
- rapid crew familiarization and training,
- mission simulation using the flight articles.

3.19 ACCESSIBILITY AND MAINTAINABILITY

3.19.1. Easy on-the-ground accessibility to the Spacelab subsystems and experiment racks is a requirement.

3.19.2. On-the-ground maintenance will be the primary maintenance mode.

3.19.3. On-orbit accessibility will be provided to experiments requiring servicing or maintenance and to subsystems that may require nonscheduled maintenance. Appropriate hand and foot holds for both internal and EVA operations will be provided.

3.19.4. Spacelab and removable GSE will be designed to provide limited access for experiment servicing during ground operations in a vertical position. As a goal, access to experiments in the module will be possible up to 4 hours before launch and immediately after landing.

3.20 INTEGRATION

Integration and mating of all Spacelab elements must be simple and reliable.

3.21 GROUND HANDLING AND TRANSPORTABILITY

3.21.1. As a goal the design of Spacelab elements (modules, module sections, pallets, pallet segments, racks, etc.) and the necessary containers and other GSE will permit as many different ground shipment options as practical.

3.21.2. Individual Spacelab elements (e.g. extension modules, pallet segments, rack sets) will be transportable in a C5A aircraft.

3.21.3. In order to facilitate complete experiment integration at the homesite of a user organization the combined Spacelab experiment equipment and experiment mounting elements (e.g. racks and pallet segments) will be compatible with shipment in a C5A aircraft.

3.22 GROUND SUPPORT EQUIPMENT (GSE)

3.22.1. In addition to the GSE required for development and at the launch/landing sites, GSE will also be needed for:

(a) experiment payload integration (excluding experiment unique GSE).

(b) operation of the Engineering Model.

(c) transportation of the complete Spacelab and Spacelab elements as required.

3.22.2. As a goal all transportation and handling equipment shall be designed to provide environments in ground operations less severe than those experienced in flight. Environment monitoring during shipment is a requirement.

3.23 CONTAMINATION

Spacelab will be designed to minimize the generation, introduction and accumulation of gaseous and particulate contaminants, both internal to the module and external to the module and pallet. The external contamination level on Spacelab missions will be consistent with the Shuttle orbiter payload bay. Spacelab will minimize particle and fluid impingement into the payload bay or any element of the Spacelab or experiment equipment.

3.24 ELECTROMAGNETIC INTERFERENCE (EMI)

The Spacelab design should minimize the generation of EMI from sources within the Spacelab. As a goal it will also afford protection to Spacelab subsystems and payloads from EMI being introduced into Spacelab from external sources.

3.25 SOFTWARE

3.25.1. As a goal Spacelab software for both subsystem and experiment support will conform to NASA Space Flight Software Standards (TBD).

3.25.2. As a goal Spacelab software for both subsystem and experiment support will be compatible with host computers in use at NASA and ESRO installations. (see par. 3.11.4.)

3.25.3. Data exchange between Spacelab and the orbiter will be formatted to be compatible with the orbiter.

3.26 SYSTEM QUALIFICATION

The Spacelab will be qualified on the ground insofar as practical, prior to acceptance of the First Flight Unit. Adequate test hardware (non-deliverable to the U.S.) is required for successful implementation of the project. As required, design and environment verification will be conducted on early flights.

3.27 ENVIRONMENT

3.27.1. Natural environment data as specified in ref. par. 2.2 (10) will be used for design and operational analyses.

3.27.2. The environments experienced by the Spacelab associated with flight operations are contained in ref. par. 2.2 (4) and subsequent revisions thereto.

4.0 OPERATIONS

4.1 GROUND OPERATIONS

4.1.1. The major steps (integration levels) in ground operational processing of Spacelab following refurbishment and of its experiment payloads are:

Level I - integration and checkout of the Spacelab and its payloads with the Shuttle orbiter, including the necessary preinstallation testing with simulated interfaces.

Level II - integration and checkout of the combined experiment equipment and experiment mounting elements (e.g. racks, rack sets and pallet segments) with the flight subsystem support elements (i.e. basic module, igloo) and extension modules, when applicable.

Level III - combination, integration and checkout of all experiment mounting elements (e.g. racks, rack sets and pallet segments) with experiment equipment already installed, and of experiment and Spacelab software.

Level IV - integration and checkout of experiment equipment with individual experiment mounting elements (e.g. racks and pallet segments).

4.1.2. Level I integration will always take place at the launch site.

4.1.3. Refurbishment and Level II integration will normally be performed at the launch site.

4.1.4. Level III integration will be possible at various spacecraft and payload development facilities (NASA and ESRO centers, other government organisations, industrial concerns, and universities). However, extensive Spacelab GSE and facilities may be required.

4.1.5. Level IV integration will be possible at user home facilities with minimum Spacelab unique GSE.

4.1.6. Spacelab will normally be installed and removed from the orbiter while the orbiter is in a horizontal attitude.

4.1.7. Spacelab will also be designed for rapid removal from the orbiter while in a vertical attitude on the launch pad.

4.1.8. Spacelab ground operations shall be as independent of the orbiter as practical.

4.1.9. The goal for ground turnaround, when Spacelab is fully operational, from the time of landing to launch for refurbishment of flight subsystem support elements (i.e. basic module, igloo), and for Level II and I integration including final prelaunch activities will be 320 working hours.

4.2 FLIGHT OPERATIONS

4.2.1. Flight operations control of basic module and igloo resources will be the responsibility of Shuttle flight control (which includes the basic orbiter crew).

4.2.2. Ground support for Spacelab housekeeping is expected to be minimal (ref. para. 3.10.2).

4.2.3. Communications and mission control will be through the Mission Control Center at JSC.

4.3 PAYLOAD OPERATIONS

4.3.1. While on-orbit Spacelab experiment operations and experiment data acquisition will be coordinated by a payload specialist.

4.3.2. Control of experiment operations may be from various payload development centers. Ground support of experiment operations will provide a capability for mission planning, real-time mission replanning, experiment operations training, data preprocessing, and interaction between the payload specialists on orbit and their colleagues on the ground.

4.4 COMMUNICATIONS NETWORK

A Tracking and Data Relay Satellite System (TDRSS) will be used for communications during orbital operations. The characteristics of the NASA communications system with the earth are described in ref. par. 2.2.11.

4.5 EXTRAVEHICULAR ACTIVITY (EVA)

4.5.1. EVA may be used on Spacelab flights for non-scheduled maintenance and repair of subsystems and experiment equipment and also as part of the experiment operation. EVA will be used for rescue (ref. par. 7.5) except on special missions carrying a docking module.

4.5.2. On Spacelab missions utilising the module, egress will be through the EVA hatch except on special flights on which a docking module is carried.

4.5.3. Concurrent EVA operations and manned experiment operations in the module are an operational goal.

5.0 SHUTTLE INTERFACE

5.1 COMPATIBILITY REQUIREMENT

The Spacelab and its experiment payloads will be compatible with the Space Shuttle as defined in the reference documents given in par. 2.2 (3) and 2.2 (4) and subsequent revisions thereto.

5.2 GROUND INTEGRATION CONSTRAINT

The subsystem support to Spacelab from the Shuttle orbiter and the interface between the orbiter and the Spacelab module or pallet shall be consistent with the allocated timeline during Spacelab to orbiter integration.

5.3 SPACELAB CONFIGURATION IMPACT

Insofar as possible, the design of the various Spacelab configurations (pallet-only, module-only and module/pallet combination) will minimize the need for different or additional interface provisions with the orbiter.

5.4 SHUTTLE SUPPORT TO SPACELAB

Spacelab will depend on the Shuttle orbiter for:

(a) transportation to and from orbit.

(b) crew accommodations for sleeping, eating, personal hygiene, health and well being, waste management and emergency refuge.

(c) one payload specialist work station on the flight deck with standard racks (2 square meters of panel area, 1 cubic meter of volume).

(d) primary power supply of 7 kw_e average and 12 kw_e peak (15 minutes maximum) on single bus.

(e) a basic energy supply fo 50 kwh supplemented by up to 5 energy kits of 840 kwh each.

(f) basic stabilization and control.

(g) guidance and navigation.

(h) maintenance of the desired orbit.

(i) heat rejection up to 8.5 kw_t with coolant supply of 5°C maximum with a coolant return of 40°C maximum.

(j) normal communications with the ground (ref. par. 3.11.2.).

(k) operational EVA (suits, equipment, expendables and trained crewmen) for 2 two-man operations.

(l) rescue operations and equipment (ref. par. 7.5).

6.0 USER REQUIREMENTS

To the extent practical, the user requirements defined by the NASA-ESRO Joint Users Requirements Group (JURG) and documented in ref. par. 2.2(9) will be incorporated into this document (i.e. the Programme Requirements document) and the Spacelab System Requirements document (i.e. ref. par. 2.2 (7)).

7.0 PRODUCT ASSURANCE AND SAFETY

7.1 HAZARD IDENTIFICATION, REDUCTION AND CONTROL

Potential hazards will be identified on all Spacelab equipment and operations (ground and flight) including:

(a) interfaces with the Shuttle orbiter, experiments and GSE.

(b) back-up and emergency operational modes.

Every attempt shall be made to eliminate potential hazards. Those hazards that cannot be eliminated shall be reduced or controlled to an acceptable risk level and flagged as residual hazards. The disposition of hazards will be an important part of all programme design reviews.

7.2 SAFE FLIGHT TERMINATION

As a goal no credible hazard associated with the Spacelab or its experiment activities shall prevent safe termination of a flights.

7.3 SELF-CONTAINED PROTECTION

The Spacelab shall have self-contained protective devices or provisions against all credible Spacelab generated hazards.

7.4 EXPERIMENT HAZARD CONTROL

The Spacelab will have specific equipment, devices and procedures:

(a) to protect the Spacelab, Space Shuttle and crew from whatever hazards may be generated by the science and applications experiment activities.

(b) to relieve the user of as much of the cost of space qualifying and man-rating his or her equipment as practical.

7.5 RESCUE PROVISIONS

7.5.1. Provisions for rescuing the full crew on-orbit will be primarily the responsibility of the Shuttle. The orbiter cabin will serve as the refuge until a rescue Shuttle arrives. The prime rescue mode will be EVA (ref. par. 4.3.1.) to another Shuttle orbiter.

7.5.2. The EVA hatch will be one of the primary rescue routes from the orbiter cabin.

7.5.3. The Spacelab module will provide for emergency exit via the transfer tunnel to the orbiter cabin.

7.6 CAUTION AND WARNING SUBSYSTEM

TBD.

7.7 RELIABILITY

7.7.1. The overall Spacelab system design and maintenance characteristics will be consistent with the design life (ref. par. 3.2). Spacelab components and subsystems shall be designed to be at least fail safe and shall be designed so as to facilitate preventive and corrective maintenance during ground operational periods. Due to potential flight repeatability, the omission of design redundancies, the utilisation of non-space qualified ("CAM") equipment and/or minimized verification requirements may be considered, where it can be clearly established that (1) personnel safety will not be compromised, and (2) significant cost savings will result.

7.7.2. Failure Mode and Effect Analyses (FMEA's) which define the effect of component failures on flight objectives shall be conducted. Retention of critical failure modes will be rigorously justified, and a "Critical Item Control" programme will be established and systematically implemented for retained critical items.

7.7.3. Prior flight and/or ground tests will demonstrate, as far as possible, that system elements are capable of meeting the flight requirements. For those system elements which cannot be fully verified by prior flight and/or ground tests, engineering analyses will substantiate their capability of meeting flight objectives.

7.7.4. A Spacelab parts programme will be established and implemented, as appropriate, which controls critical parts procurement, selection, screening, evaluation, qualification, derating, failure analysis, acceptance testing, handling, storage, application reviews, and configuration control.

7.7.5. A closed loop system for failure reporting, analysis and corrective action will be established and implemented for failure occurring on critical components or systems.

7.8 QUALITY ASSURANCE

A Spacelab Quality Assurance Program will be established for controlling the following major activities:

(a) Design and development.

(b) Identification and data retrieval.

(c) Procurement.

(d) Fabrication.

(e) Inspection and testing.

(f) Nonconforming articles and materials.

(g) Metrology.

(h) Handling.

(i) Government furnished (NASA/ESRO) equipment.

7.9 MATERIALS CONTROL

TBD.

8.0 PROGRAMME COST CONSIDERATIONS

8.1 COST

Overall programme cost will be a major consideration in all major design and operational concept decisions.

8.2 PRODUCTION AND OPERATIONAL COSTS

To enhance the utility of the Spacelab to the operator and to potential users, it is desirable that the cost of production units, including spares, and operational costs (i.e. integration, checkout, maintenance and refurbishment) be kept to a minimum.